

## A Cryptological Conundrum

One brisk spring morning, Twilight Sparkle was roused hours before the sun's rising by a loud retching sound emanating from the foot of her bed. With a groan, she pushed herself up on her pillow.

"Oh, for Celestia's sake, Spike! I told you not to eat all that malachite before you went to bed, you know it gives you a tummy ache! Ugh, I'll get the paper towels..."

As she stepped out of bed, she saw Spike sitting up in his basket, holding a scroll. "Um, Twilight?" he said, "You'd better take a look at this..."

"What is it?" She leaned over his shoulder, her sleepiness forgotten in a rush of curiosity. "A letter from the Princess? Why would she write to me at this hour?"

Spike cleared his throat and began to read:

*My dearest, most faithful student, Twilight,*

*I fear I must write you with grave news. Relations with the Dragon Empire are extremely delicate, as you know, and it is crucial that Equestria present a united front in our negotiations with them. Any sign of weakness on our part could be viewed as an opportunity for conquest. Although you were not yet foaled at the time, I'm sure you've read stories of the Dragon War, and are aware that it would be disastrous if we were to be forced into military conflict with their nation once more.*

*However, I now fear that my chief diplomat to the Empire, one Russet Cape, has begun selling secrets to the dragons. I do not have any proof positive, but my spies have intercepted a letter of his, written in a cypher unknown to me or my court.*

*I am sending a full transcription of the intercepted document, in hopes that you will have more luck deciphering it than my counterespionage unit has had so far. This letter was sent from Russet to the Dragon Emperor two nights ago. The only clue we have to its solution is that, in a letter he sent last week, Russet mentioned that he had started working on a 'percentage cypher.' What that might be, I am not sure.*

*The message follows:*

112, 760, 777, 023, 221, 678, 234, 495, 047, 885, 782, 034, 347, 123, 734, 364, 989, 089, 222, 056, 578, 099, 371, 166, 386, 084, 011, 445, 897, 822, 641, 311, 565, 770, 560, 225, 322, 599, 928, 921, 180, 467, 906, 267, 175, 690, 455, 899, 566, 212,689, 046, 337, 854, 157, 753, 235, 089, 114, 909, 600.

*I'm sure I don't need to tell you how vital it is to solve this enigma as quickly as possible. Please, devote all your resources to finding the message hidden in this letter.*

"By Celestia's beard! Spike, do you know what this means?!"

"Um, no?"

"Quickly, to the library!" Twilight dashed downstairs, snatching the letter from Spike as she ran.

Spike groaned. "Oh, *that's* what it means. It means I'll be spending my morning picking up after you." And with that, the young dragon yawned and slumped after the purple unicorn.

*[A.N. If you want to figure out the riddle on your own, stop right here! If you need a few hints, go ahead and read the next section; Twilight's got some ideas. But DON'T finish the story unless you want to have the solution spoiled for you!]*

Dawn found Twilight furiously scratching notes on a piece of parchment, while Spike looked over her shoulder, incomprehension writ wide across his face.

“Okay Twilight, I’ve got all those code books put away again. Now are you going to tell me what those numbers in the Princess’s letter mean?”

Twilight rolled her eyes. “That’s what I’m *trying* to figure out, Spike. Can’t you see I’m busy?”

Spike stared in confusion at the scroll Twilight was writing on. It was just a bunch of letters and numbers:

E = 11.7

I = 8.6

S = 8.1

A = 8.0

R = 7.4

N = 7.4

T = 6.8

O = 5.9

L = 5.3

C = 4.1

D = 3.8

U = 3.2

G = 2.8

P = 2.8

M = 2.7

H = 2.2

B = 2.0

Y = 1.7

F = 1.4

V = 1.1

K = 0.9

W = 0.9

Z = 0.5

X = 0.3

J = 0.2

Q = 0.2

It was all meaningless to him. Spike shook his head, then decided to try another tack.

“Look, if there could be a war, then I want to help you find a way to stop it. I understood that part of the Princess’s letter. But I don’t understand all this other stuff. What’s a ‘cypher?’ And what did all those numbers mean?”

“Spike, I really don’t have time for this right now!” Spike jumped at her harsh tone, but Twilight sighed and slumped her shoulders a moment later. “I’m sorry, I didn’t mean to yell...but this is important! The Dragon Empire borders on some of the most heavily populated lands in Equestria, and even a short conflict would be devastating. In the last Dragon War, over three million ponies died, and I have to do everything I can to stop that from happening again!” She scooped up some blank papers and a quill, and deposited them in front of Spike. “Here, I’m about ready to start testing the various permutations of potential keys. You can help me with that if you want; it’ll be boring, but it’s vital that we

work as quickly as we can.”

Spike scrunched up his face. “Permu-wha?”

Twilight facehoofed. “Look Spike, do you remember when you came up with that ‘secret code’ for your diary?”

“Yeah, of course...I also remember that when you solved it, you made me sleep outside for a week just because I mentioned that I didn’t like having to clean up after you all the time.”

“You called me a stuck-up goat, Spike! And anyway, your ‘code’ was just 1 = A, 2 = B, and so on. It didn’t take a genius to figure it out. Also, technically that was a cypher, not a code.”

“So back to square one, then. What’s a cypher?”

“A cypher means that you’re replacing individual letters with other symbols. For your diary, you used what’s called a ‘substitution cypher:’ you just replaced each letter with a single symbol. Needless to say, this cypher is far more complex.”

“Well, what have you figured out so far?”

“The Princess referred to it as a ‘percentage cypher.’ I remember reading about such a thing while I was a student in Canterlot. Each letter has a set of numbers that can represent it, corresponding to the frequency with which that letter appears in text. The theory was that it would be impossible to crack, because each number would appear with equal frequency. Normally, cyphers can be solved by looking at symbol frequency or finding doubled symbols which correspond to doubled letters, but this particular type of polyalphabetic cypher neatly bypasses both problems. However, I think I’ve figured out enough to get us started.”

Twilight laid out a list of percentages she had copied from one of her code books. “This is from one of the most readily available books on the history of coded texts in Equestria. Russet Cape would undoubtedly have access to it. Now, I noticed something interesting: it lists the frequency of each letter based on an analysis of common words, and gives them to the nearest tenth of a percent. Now, if you look here,” She pulled up the Princess’s letter, “You’ll see that all of the numbers used in the cypher are between 023 and 989. It seems reasonable to guess that Russet used the numbers 0-999 for his cypher. Do you see what this means?”

“...No?”

Twilight sighed dramatically. “I *could* be mistaken, but the most plausible explanation is that Russet simply assigned numbers based on the percentages found in this book. So,” she referenced the scroll of percentages again, “If A = 8.0, that means that in a typical document, approximately eight out of every one hundred letters will be an A. So, Russet assigned 80 numbers between 0 and 999 to that letter, and any one of those 80 numbers could be written to mean A. And he did this for every letter.”

Dawning comprehension flashed across Spike’s face. “Oh, I get it! I think. But how do we solve it?”

“If we had a larger sample, we could start by looking for Q’s and U’s. There are only two numbers used to represent Q, and 32 used to represent U. Since Q must always be followed by U, it would be possible (if we had enough text to analyze) to find two numbers that are always followed by one of the same 32 other numbers. But, when we’re trying to decipher something this short...” She threw her hooves in the air. “We’re just going to have to brute force it.”

“Should we get Rainbow Dash and Applejack, then?”

“Not THAT kind of brute force! I mean we’re going to have to try combinations of letters and numbers one at a time until we find the key. There is one clue, though: The number 089 appears twice in the document. It’s the only number that’s repeated. It *could* be a coincidence, but I suspect 089 has to represent one of the least common letters. And in any case we can be sure, if our base conjecture is correct, that 089 represents the same letter both times.”

“Okay Twilight, but what if you’re wrong about all this? We’re putting a lot of faith in *coulds* and *probablys*.”

“I know Spike, but I don’t see any other way. Besides, the Princess’s letter indicates he only recently began working on this cypher. I doubt he had time to do anything too fancy. This would be hard to crack, but easy to put together. It fits the situation perfectly.”

“Alright. So now what?”

“Like I said, Spike: brute force. Grab your quill, and start writing down number lists for each letter using the percentages on this sheet. Then use the key you just created to translate Russet’s document. If it doesn’t make for a legible letter set, make up a new key and try again.”

Spike frowned. “That sounds like a lot of work.”

“Oh, it will be. But I can’t think of any other way.”

*[A.N. Just because Twilight can’t think of one, doesn’t mean there isn’t a better way to solve this type of cypher. Also, DON’T READ THE NEXT SECTION UNLESS YOU WANT THE SOLUTION SPOILED!]*

Seven hours later, the baby dragon and the purple unicorn were still labouring over their number lists. Spike crossed his fingers as he prepared to test his latest key.

It translated Russet’s message as EEFJ IOPWQK LLEAIIBZAAAACMNMOAPUMAEIOIHEEOP LH  
FBAOBAAEIEUEEWZNNV.

Groaning with frustration, Spike threw down his quill. “That’s it, Twilight! We’ve been working on this forever, and we haven’t gotten a single useful result. It’s hopeless!”

“Now Spike, be patient. There’s a lot of possible keys out there, and we’ve only analyzed...” She did some quick mental arithmetic, then collapsed in defeat. “...Oh goodness, I’d need to teach you scientific notation just to tell you what fraction of a percentage of all possible keys we’ve analyzed so far.”

At that moment, Pinkie Pie burst through the door. “Heya, Twilight! Aren’t you gonna come to the party?” She looked around at the exhausted pony and dragon, and the sheets of paper scattered all over the library. “Ooh, looks like you’re doing something boring! What is it?”

Twilight harrumphed. “*We* are working to save millions of lives, while *you* are out planning parties. Now please, Pinkie, I’m not in the mood to deal with you right now!” And with that, she returned her attention to the scroll in front of her.

Spike, on the other hand, was glad for any interruption. Besides, his hands were starting to cramp; he desperately needed a rest. Walking over to Pinkie, he explained, “Sorry about Twilight. She’s under a lot of stress with this note that the Princess sent her. She has to crack a code-I mean, a cypher-and it’s not going well.”

“Ooh, so you’re playing secret agents? That sounds like fun! Here I thought you were just doing something super-cerebral with all those pages of math-y stuff! Show me the secret code, Spike!”

Spike glanced over at Twilight, who had tuned out their conversation and returned to crafting her latest key. The original letter from the Princess lay discarded on the table; she and Spike had both memorized the short list of numbers by their second hour of work.

“Well, I suppose it couldn’t hurt to show you the letter...but it’s got some sensitive information. You can keep a secret, right?”

“Cross my heart and hope to fly, stick a cupcake in my eye!”

Satisfied, Spike grabbed the Princess’s letter from the table and gave it to Pinkie. “If you’ve got any ideas, we could use some help. Of course, after all the time and energy Twilight’s put into this, I doubt you’re likely to have a miraculous breakthrough...” He paused as Pinkie put her nose up to the scroll and inhaled deeply. “Um, Pinkie? What are you doing?”

Pinkie scrunched up her face. “Do Celestia’s letters always smell like lemons?”

“Lemons? Let me see that...” Spike took the scroll, and gave it a tentative sniff. Sure enough,

there was a faint aroma of citrus on the paper. “Huh, that’s weird…”

“AH-HA!” screamed Pinkie, startling Spike and causing Twilight to jump right out of her chair. “I’ve got it!” With that, she grabbed the scroll and rushed back out the door.

“Spike, what’s going on? Where did Pinkie go?”

“I don’t know! She just grabbed the Princess’s letter and ran outside!”

Twilight leapt to her feet and rushed for the door. “Well, come on Spike! We have to stop her from showing that scroll to anypony else!”

The two friends bolted out the door, only to run right into Pinkie Pie. She was holding the note up to the sun and smiling brightly. She turned to face the confused Twilight and Spike with a look of triumph on her face. “Wow, I didn’t know that Celestia was so tricky. She really got you, huh? But I guess that’s a good thing; you don’t want to make your teacher lose a bet, do you?” And with that, she tossed the scroll negligently to Spike and pranced off. As she left, she called over her shoulder, “Once you send that letter, be sure to drop by Sugarcube Corner! We’ve already started the April Foeal’s Day party!”

Twilight stood stock-still, shocked into immobility. “Celestia? Bet? April Foeal’s Day?”

Spike picked up the letter and held it up to the sun as Pinkie had. To his surprise, the previously blank bottom of the scroll was revealed to be filled with faint script, invisible without strong back-lighting. He read aloud:

*My faithful student,*

*I’m sure you never heard of it when you were living in Canterlot, but among the outlying communities of Equestria there is a holiday celebrated on the first of April every year. They call it ‘April Foeal’s Day,’ and it is an entire day dedicated to playful jests, practical jokes, and other childish behaviour. Since this is your first April Foeal’s Day in Ponyville, I thought I might introduce you to the tradition with a little lighthearted prank of my own. Don’t worry about that silly code; Russet Cape divulged the key to my ‘enhanced interrogation specialists’ after only a brief visit to Canterlot’s ‘basement-area questioning facilities.’ He’s doing ‘very well,’ now that all this unpleasantness has been cleared up.*

*P.S. I bet Luna twenty bits that your pink earth pony friend would be the one to ‘find the message hidden in this letter,’ as I put it above. Would you be a dear and send a note right away telling me who won our little wager?*

Spike looked up at Twilight nervously. She was standing motionless, save for a persistent twitch in her left eye. Her mouth was ajar, and her entire appearance suggested nothing so much as catatonic shock. “So, ah, heh heh, pretty funny, right Twilight?”

Twilight didn’t answer right away. Just as Spike was starting to worry for her sanity, she slowly turned her head to face him.

“Spike, take a letter.”

A few minutes later, in Canterlot Castle’s throne room, a tightly bound scroll popped into existence in front of Princess Celestia. Muttering “About time,” under her breath, Celestia opened the message and read,

*Dear Princess Celestia:*

*WHAT. THE. HAY.*

*-Your faithful student, Twilight Sparkle.*

*P.S. Sorry about Twilight; she's had a long day. Also, you totally won that bet.*

*-Spike*

The princess grinned at the broken and battered pony strung up across from her. “Well, that just makes it all worthwhile, knowing my prank went off exactly as planned. I hope you know how much I appreciate your contribution to this little joke of mine, Russet. I really couldn’t have done it without you. In any case, see you at dawn!” With that, she waved dismissively at the miserable figure before her, and two guards rushed over to haul him back to his ‘prisoner’s suite.’ Taking a blank form from the stack beside her, she checked the boxes for ‘traitor,’ ‘hanging,’ and ‘dawn.’ She signed it, then smiled. “I do so love planning executions.”

*[A.N. Admit it, you thought I was going to leave you hanging! Never fear, that's an actual cypher that Russet used, and here's the actual solution. If any of you figured it out without peeking, get yourselves a congratulatory muffin and rejoice! Without further adieu, Russet's letter to the Dragon Emperor (spacing and punctuation added):*

Testing new cypher. If able to translate, respond using same key to confirm.

*EXCITING, isn't it? Happy April Foa!s Day!]*